PROFESSIONAL ENGINEERS ONTARIO
NATIONAL EXAMINATIONS –December 2014
GEOTECHNICAL MATERIALS AND ANALYSIS

3 HOURS DURATION

NOTES:

1. This is a **closed book** examination.
2. Read all questions carefully before you answer
3. Should you have any doubt regarding the interpretation of a question, you are encouraged to complete the question submitting a clear statement of your assumptions.
4. The total exam value is 100 marks
5. One of two calculators can be used: Casio or Sharp approved models.
6. Drawing instruments are required.
7. All required charts and equations are provided at the back of the examination.
8. YOU MUST RETURN ALL EXAMINATION SHEETS.

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ANSWER ALL QUESTIONS

Question 1: **(4 x 5 = 20 marks)**

State the correct answer for each of the questions below and **provide reasons** to **JUSTIFY THE STATEMENT IN YOUR ANSWER BOOK.**

(i)	Which one of the following soils: (A) sand; (B) silt or (C) clay will have a higher optimum moisture content (OMC)?
(ii)	Which one of the following soils (A), sand (B) silt or (C) clay will have a higher coefficient of permeability?
(iii)	A clay specimen was compacted at different compaction water contents (A) wet of optimum; (B) optimum; and (C) dry of optimum. Which one of these will give a higher unconfined compressive strength?
(iv)	Which one of the soils (A) Normally Consolidated clay; (B) Over Consolidated clay will have a higher compression index, C_c? Provide your reasons.
(v)	Which one of the soils (A) Normally Consolidated clay or (B) Over Consolidated clay will have a higher effective cohesion value?

Question 2: **(10 marks)**

Briefly explain the three different "limit" lateral earth pressures (i.e., at-rest, active, and passive conditions) that can act on a retaining wall. Also, show the Mohr circle for each condition (Note: You are expected to draw simple sketches of retaining walls and Mohr failure envelopes for the three cases; **Figure 1** is shown below as an example without providing the key details).

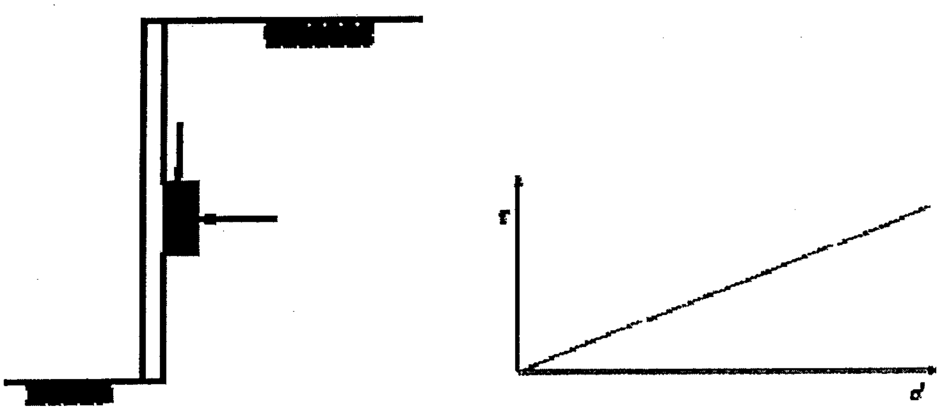


Figure 1

Question 3: **(10 marks)**

Clearly explain how seepage affects the stability of a homogeous earth dam constructed with a silty sand. Describe any two measures you would recommend to improve the stability characteristics. Supplement your answer with a neat sketch.
(Hint - The key words that can be used in answering this question: pore-water pressures, effective stress, seepage stress, critical hydraulic gradient, shear strength etc)

Question 4: **(Value: 20 marks)**

Figure 2 shows the plan view of a condominium structure. The foundation of the building (shaded area) will be loaded with a uniform stress of 50 kPa. Determine the increase in vertical stress $\Delta\sigma_z$ due to the load, at depths of **2 and 5 m** vertically below **point A** (Use superposition method). Comment on the stress values determined at different depths and how this information is useful for a geotechnical engineer.

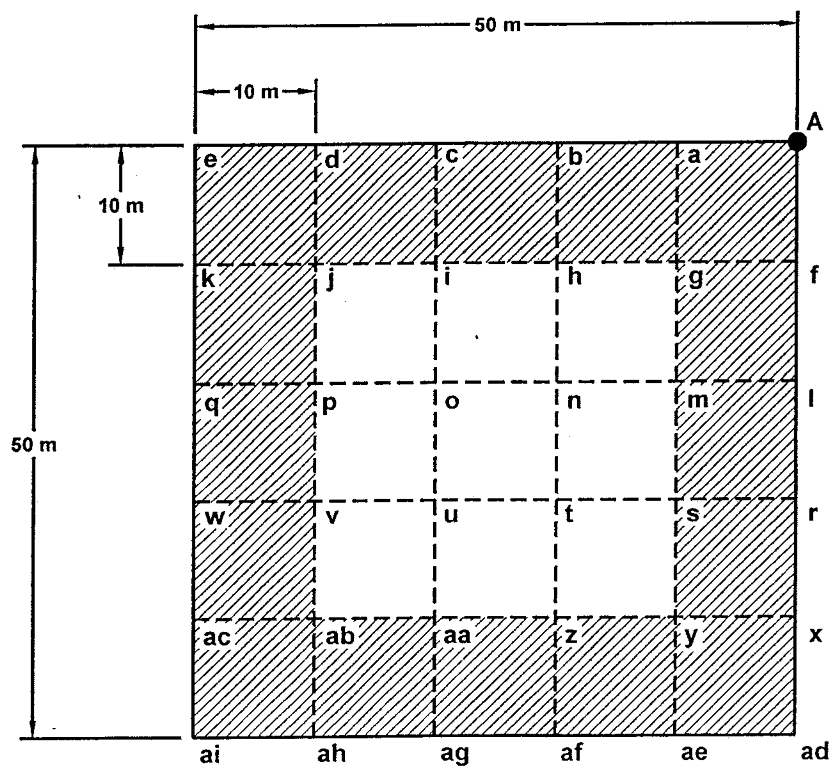


Figure 2

Question 5: **(Value: 20 marks)**

For a cutoff wall shown in Figure 3

a. Establish the flow net (i.e. flow and equipotential lines) following all the rules (draw on Figure 4). **(15 marks)**

b. Determine the quantity of seepage (m^3/s per m) (coefficient of permeability, $k = 2.0 \times 10^{-5}$ m/s). **(5 marks)**

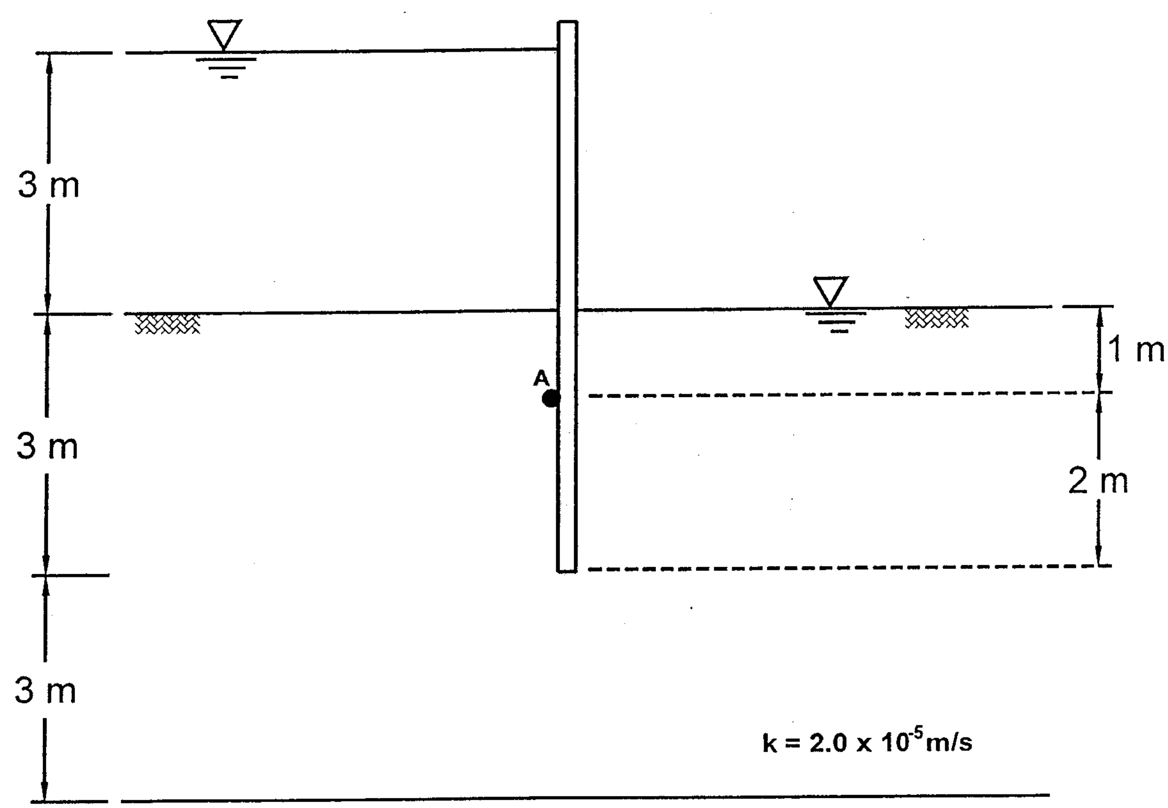


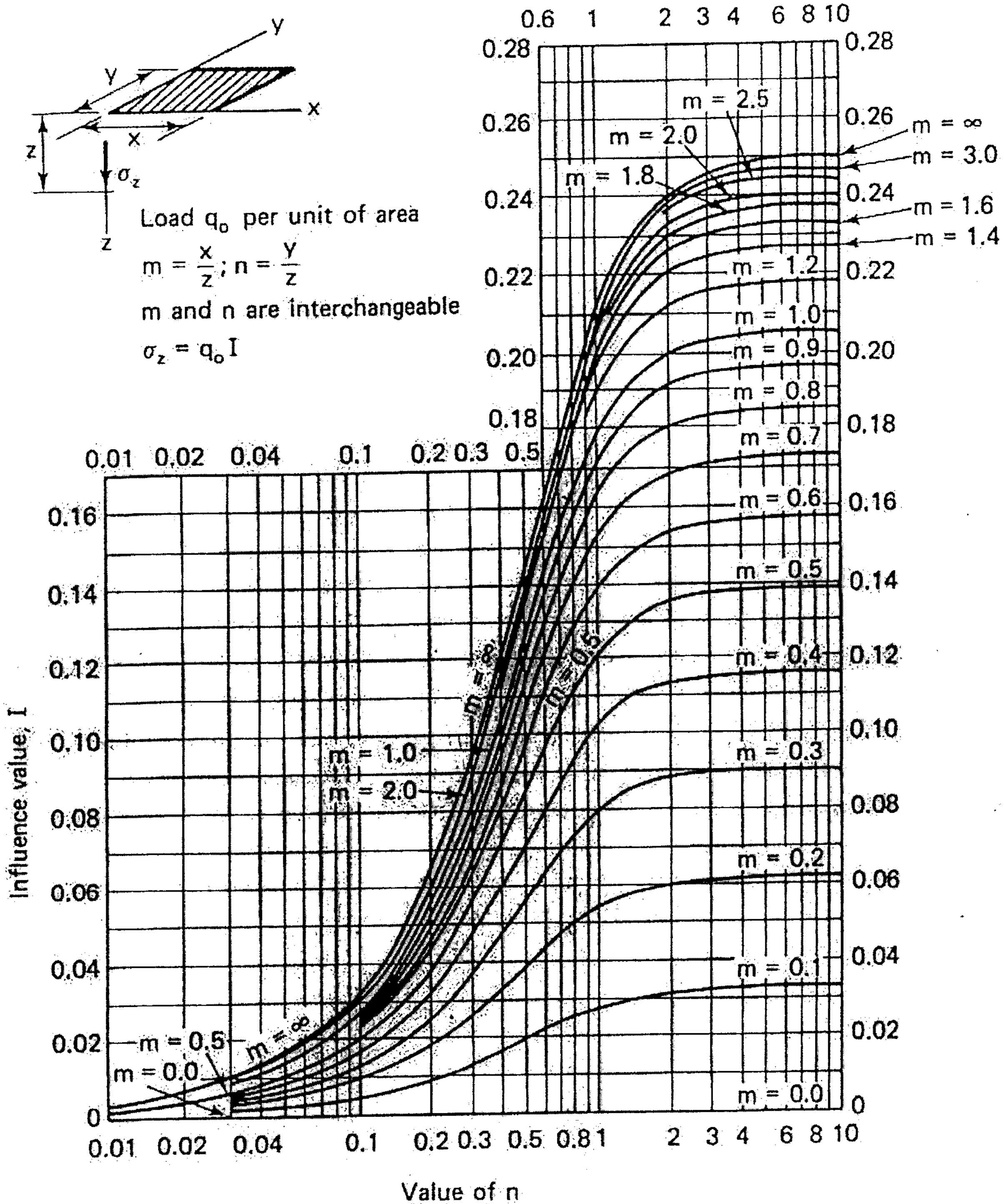
Figure 3

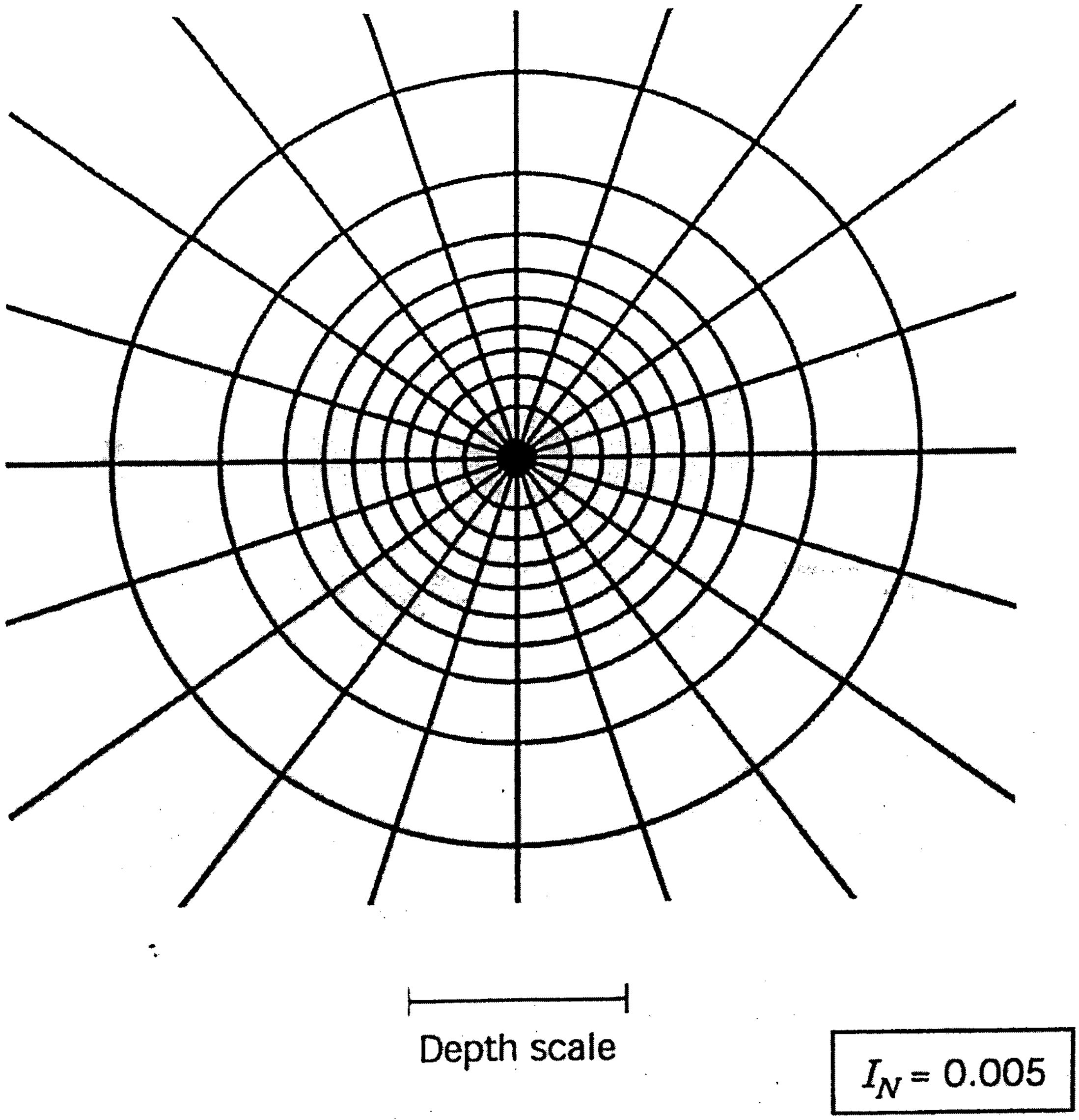
Question 6: **(Value: 20 marks)**

Triaxial shear tests were conducted under CD conditions on saturated clay specimens and the effective shear strength parameters were determined as: $c' = 10$ kPa and $\phi' = 28^{o}$. Another triaxial shear test was conducted on an identical saturated clay specimen under CU conditions. Determine the applied vertical total stress (σ_1) that will be acting on the clay specimen at failure conditions, when the applied confining total stress, $\sigma_3 = 100$kPa and the measured pore-water pressure, $u_w = 40$ kPa.

(i) The boss, senior geotechnical engineer has asked you, the junior geotechnical engineer to conduct the CU test (as stated in the problem above at a confining stress of σ_3 = 100 kPa) to derive some practical information. Explain clearly the information that the senior geotechnical engineer has in mind that can be derived from this test.

(ii) When do you recommend performing CD and CU tests? Give a practical example for both these tests, providing details.


Load q_0 per unit of area
$m = \frac{x}{z}$; $n = \frac{y}{z}$
m and n are interchangeable
$\sigma_z = q_0 I$
Influence value, I
Value of n
m = ∞
m = 3.0
m = 2.5
m = 2.0
m = 1.8
m = 1.6
m = 1.4
m = 1.2
m = 1.0
m = 0.9
m = 0.8
m = 0.7
m = 0.6
m = 0.5
m = 0.4
m = 0.3
m = 0.2
m = 0.1
m = 0.0


Depth scale
I_N = 0.005

Formula Sheet

$G_s = \frac{\rho_s}{\rho_w}$ $\rho = \frac{(Se+G_s)\rho_w}{1+e}$ $\gamma = \frac{(Se+G_s)\gamma_w}{1+e}$ $wG = Se$

$\sigma = \gamma D$

$P = \sum N' + u A$

$\frac{P}{A} = \frac{\sum N'}{A} + u$

$\sigma = \sigma' + u$ (or)

$\sigma' = \sigma - u$

For a fully submerged soil $\sigma' = \gamma' D$

$v = ki$; where $i = h/L$; $q = kiA$; $\Delta h = \frac{h_w}{N_d}$

$q = k \cdot h_w \cdot \frac{N_f}{N_d}(width)$; $h_p = \frac{n_d}{N_d} h_w$

Boussinesq's equation for determining vertical stress due to a point load

$$\sigma_z = \frac{3Q}{2\pi z^2}\left\{\frac{1}{1+\left(\frac{r}{z}\right)^2}\right\}^{5/2}$$

Determination of vertical stress due to a rectangular loading: $\sigma_z = q I_c$ (Charts also available)

$m = B/z$ *and* $n = L/z$ (both m and n are interchangeable)

Approximate method to determine vertical stress, $\sigma_z = \frac{qBL}{(B+z)(L+z)}$

Equation for determination vertical stress using Newmark's chart: $\sigma_z = 0.005\,N\,q$

$\tau_f = c' + (\sigma - u_w)\tan\phi'$; $\sigma_1' = \sigma_3' \tan^2\left(45^o + \frac{\phi'}{2}\right) + 2c'\tan\left(45^o + \frac{\phi'}{2}\right)$

Mohr's circles can be represented as stress points by plotting the data $\frac{1}{2}(\sigma'_1 - \sigma'_3)$

against $\frac{1}{2}(\sigma'_1 + \sigma'_3)$; $\phi' = \sin^{-1}(\tan\alpha')$ *and* $c' = \frac{a}{\cos\phi'}$

$\frac{\Delta e}{\Delta H} = \frac{1+e_o}{H_o}$; $s_c = H\frac{C_c}{1+e_o}\log\frac{\sigma'_1}{\sigma'_o}$; $s_c = \mu\, s_{od}$; $m_v = \frac{\Delta e}{1+e}\left(\frac{1}{\Delta\sigma'}\right) = \frac{1}{1+e_o}\left(\frac{e_o - e_1}{\sigma'_1 - \sigma'_0}\right)$

$$\frac{t_{lab}}{d_{lab}^{\ 2}} = \frac{t_{field}}{\left(H_{field}/2\right)^2}$$

$$T_v = \frac{c_v t}{d^2}\ ;\ T_v = \frac{\pi}{4}U^2 \text{ (for U < 60\%)}$$

$$T_v = -0.933\log\left(1-U\right) - 0.085 \text{ (for U > 60\%)}$$

$$C_c = \frac{e_o - e_1}{\log\left(\dfrac{\sigma_1'}{\sigma_0}\right)}$$; also, $C_c = 0.009(LL - 10)$;